## NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS OF ASTRONOMY DURING THE PAST YEAR.

### *The Numerical Lunar Theory.*

The Numerical Lunar Theory, on the state of which the Astronomer-Royal has occasionally given some Reports to the Society, has advanced steadily, interrupted only by some errors in operations incurred by an assistant's trusting too much to his own judgment and accuracy. With the view of placing the work which is done in a position of safety against ordinary contingencies, a considerable portion has been already printed, in readiness for ultimate distribution, both as an Appendix to the *Greenwich Observations* and as an independent treatise. The following is the general state of calculations and of printing:—

The general form of the theory is drawn up, nearly in the same shape in which it was first exhibited to the Society (omitting for the present the terms depending on the Earth's oblateness and the change of the plane of the ecliptic), and is printed.

The first step in the application of the theory is, to develop for the left side of each of the three theoretical equations (that is, the side which depends entirely on the actual place of the Moon, but without explicit reference to perturbing forces) all the successive steps leading up to that left side as derived from Delaunay's numerical values of the three co-ordinates; which values are supposed to be not true, but so near to the truth that the squares of the corrections which they require may be neglected. This development is exhibited in numerical tables of great extent. There are 39 columns, each exhibiting a separate development as one of the steps towards the completed development of the left sides; the terms of each column consist of multiples of sines or cosines with different factors and different arguments; and the number of these terms in each column varies from 100 to 287, all carried to the 7th decimal. The whole of these results are printed.

The next step is—supposing each of Delaunay's terms to require a correction, which, before its magnitude is ascertained, must be used in the shape of a Symbolical Variation (S.V.)—to find the factors of these S.V. of Delaunay's terms, by application of which the S.V. of the terms of the left side of the equations will be formed. The theory of this transformation is printed; all preparations for the transformation are prepared, and nearly all the work is done.

It has been found desirable to abandon the use of the "Equation of Virtual Velocities," adopted in the first sketch of the theory, and to substitute for it the "Equation of Radial Forces." The addition which this change introduces into the calculations is small.

It will be seen, therefore, that the left sides of the equations are very nearly completed. The Astronomer-Royal contemplates the possible extension of some terms on which the more accurate movements of the apse and node depend; and, indeed, the work has been begun; but it is not absolutely necessary for the principle of the general theory, and the extension is for the present suspended.

Of the right side of the equations, which contains the computed perturbing forces, a large portion has been some time since completed, and the Astronomer-Royal contemplates a very early devotion of the powers of the establishment to the computation of the whole perturbation-side, and to the exhibition of the detailed equations which contain the solution of the whole problem.

## *Reduction of the Observations of the Transit of Venus, December* 8, 1874.

In the Annual Report of the Council last year, page 177, the state of the Reductions was described in considerable detail. They have been continued throughout the year under Captain Tupman, assisted by Lieutenant Neate, R.N., until November, and generally four computers. The great mass of the work, prepared on skeleton forms, has been done outside the Royal Observatory. Referring to the headings of the last Report:—

(1.) All observations with transit instruments, for local time and longitude, are completely reduced.

The longitudes of Honolulu and Rodrigues by the observations of the Moon in zenith distance, are completely reduced. These two calculations required the use of three millions of figures. The zenith point of the vertical circle employed at Rodrigues was subject to variations not yet explained, and it is possible the longitude may require a slight correction.

For Kerguelen's Island, chief station, the transit work, comparisons of clocks, latitude, and instrumental constants of the Altazimuth are reduced. The observed azimuths of the Moon, about 130 in number, and each compared with a star, and the interpolations of the Lunar elements, are in hand.

An element of great importance in the reduction of these longitudes is the amount of the correction to be applied to the Moon's Tabular Place. This is the subject of a separate communication to the Society by Captain Tupman, which will be printed in a future number of the *Monthly Notices*.

(2.) The differences of longitude between the various stations in the Hawaiian Islands and between Honolulu and San Francisco are nearly concluded.

(3.) The *Greenwich Sidereal Times* of every photograph, micrometric measure, and other observation, in Egypt, Honolulu and Rodrigues, and of every photograph at Roorkee (Colonel Tennant's station) during the actual Transit, have been adopted, employing provisional longitudes for Honolulu and Rodrigues founded on the meridional observations of the Moon.

(4.) The whole of the calculations necessary to compare the proportions of Mr. De La Rue's material scale with its image as photographed 24 times by each of the five photoheliographs have been performed in duplicate, and the means of the results have been taken for each picture. For two of the instruments, the computation of the distortion has advanced another stage—that of arranging it in angular directions around the centre of the field. In this work, 2,800 pages of ordinary foolscap size were closely covered with figures. There remains to deduce the curve of distortion in the different azimuths, and to convert the results into a form convenient for application to the measures of the Solar photographs.

(5.) Mr. C. E. Burton continued the measurement of the photographs until the end of April 1876, when, unable any longer to support the great strain upon his eyesight, he was compelled to abandon the work. During the seven months he was engaged upon it he made upwards of 38,000 bisections with the microscopes.*

The following is a list of the photographs of the actual transit measured by him:—

Thebes (Egypt).—*Ingress.*

34 square plates with *Venus* entirely within the Sun.

28 small pictures † on a circular plate with *Venus* at internal contact.

55 small pictures on two circular plates, the planet being bisected on the Sun's limb.

Honolulu.—*Ingress.*

12 square plates with *Venus* approximately bisected on the Sun's limb.

38 square plates with *Venus* entirely within the Sun.

Rodrigues.—*Entire Transit.*

24 small pictures (*Ingress*) immediately after external contact.

23 small pictures (*Ingress*) about the time of bisection.

---

* We are happy to state that Mr. Burton, who is now First-Assistant at Dunsink Observatory, has entirely recovered.

† By *small pictures* are meant those containing only that portion of the Sun's limb contiguous to the planet. On *square* plates the Sun is always entire. All the measurements are along the line of centres.

37 small pictures (*Ingress*) about the time of internal contact, *Venus* entire.

35 small pictures (*Ingress*) just after internal contact, *Venus* entire.

52 square plates during transit.

27 small pictures at *Egress* just before internal contact, *Venus* entire.

Burnham, New Zealand.
13 square plates at *Mid Transit.*

Kerguelen's Island.
Attempts were made to measure 8 square plates (at *Mid Transit*), but the photoheliograph appears to have been hopelessly out of focus on the day of the transit.

Roorkee.—*Entire Transit.*
53 small pictures at *Ingress*. *Venus* approximately bisected.
84 square plates during transit.
7 square plates at *Egress*. *Venus* approximately bisected.

Melbourne.—*Entire Transit.*
3 square plates at *Ingress*. *Venus* approximately bisected.
26 square plates during transit.

Sydney, N.S.W.—*Entire Transit.*
20 square plates during transit. *Venus* entire.

Eden, N.S.W.—*Entire Transit.*
16 square plates. *Venus* entire.

Woodford, N.S.W.—*Entire Transit.*
20 square plates. *Venus* entire.

Some 300 small pictures taken at Roorkee, Melbourne, and Sydney have not yet been measured; nor have any measurements yet been made for the distortion of the instruments used at these stations, Eden and Woodford.

(6.) The Tabular *local* distances of the centres of the Sun and *Venus* as affected by parallax, and the factors of corrections to distance for time and parallax, have been computed for every photograph, micrometric measure, and other observation of the actual transit in Egypt, Honolulu, Rodrigues, and for every photograph at Roorkee.

The work remaining may be briefly stated as follows :—

The completion of the longitudes of Kerguelen and Burnham, N.Z., by the Lunar observations, and of Honolulu and dependencies from San Francisco by chronometers, and of the distortion of the five photoheliographs; the determination of the distortion of the Indian and Colonial photoheliographs, including the measurement of the necessary photographs; the measurement of the remaining Sun pictures; the calculation of the local elements for Waimea and Kailua (Hawaiian Islands), Burnham, N.Z., Kerguelen (3 stations), Melbourne, Sydney, Eden, and Woodford; and, lastly, the treatment of the results.

It is impossible to form an even moderately accurate estimate of the time which will be required to finish all this work. It was hoped that more would have been done during the past year, but unexpected delays occurred, one of which was a serious illness of Captain Tupman, which totally incapacitated him for work for three months; other delays are caused by the necessity which often arises of going again over work believed to be free from error.

It is not proposed to commence the printing until the calculations are further advanced.

### *M. Le Verrier's Planetary Researches.*

In the address of Professor Adams delivered at the last Anniversary Meeting of the Society, a complete abstract is given of M. Le Verrier's planetary investigations as far as chapter xxiii., and now the Council have much pleasure in recording that at the *séance* of the Academy of Sciences held on November 20, 1876, chapters xxiv. to xxvii. of his *Recherches Astronomiques* were communicated by him, containing the detailed explanations of the theories of *Uranus* and *Neptune*, which thus complete his laborious researches on the theories of the eight principal planets. Tables of *Uranus* were presented in manuscript to the Academy at the same time. In this immense work M. Le Verrier has been able to follow the same system throughout his investigations, owing principally to the long-continued series of planetary observations made at the Royal Observatory at Greenwich from 1750 to the present day, which have been reduced with great order and precision, and made available for his purpose in such a form as cannot be found elsewhere. M. Le Verrier remarks that since the discovery of *Uranus* in 1781, a very large number of accurate observations have been made; and on account of its small magnitude the planet has been observed with the same accuracy as a star. For this reason, the observations made during the ninety-two years from 1781 to 1873 have been exclusively employed in the present investigation. In the comparison of the theory with the observations, the latter are represented with the precision that might have been expected from their small probable error.

The Tables of *Uranus* and *Neptune*, forming chapters xxviii. and xxix. of the *Recherches Astronomiques*, are both ready for the press, and the printing, it is expected, will proceed without interruption. The Council cannot refrain from offering to their distinguished Associate their sincere congratulations on the near and successful termination of his great undertaking.

## *The Nautical Almanac for* 1880.

In the *Nautical Almanac* for 1880, an important addition has been made to the list of standard stars, ordinarily used for the determination of instrumental and clock-errors, the apparent places of which are given for every ten days throughout the year. In observatories where observations are made at all hours of the day and night, it is highly desirable that there should be a quick succession of clock-stars, not only for the convenience of the observer in his ordinary work, but also in continuous unfavourable weather when the available time of observation is frequently confined to the few minutes interval during temporary breaks in the clouds. This extended list will, therefore, be found very useful in observatories where the observations of stars are confined mostly to those for which apparent places are given in the *Nautical Almanac*. The new stars have been selected principally from the Greenwich clock-star list, which is annually prepared for use at the Royal Observatory, and freely circulated among the principal home, foreign, and colonial observatories. These additional apparent places of the stars given in the *Nautical Almanac* for 1880 will also be a great boon to the computer, who will in consequence be relieved of a considerable amount of daily calculation. Possibly at some future time space will be found in the Almanac to include most of the stars in the Greenwich list; meanwhile, astronomers are much indebted to the Superintendent for his very valuable and voluntary addition to our national ephemeris. As the standard stars have been well observed at Greenwich during the nine years from 1868 to 1876, it is hoped that the adopted mean places will be taken, as soon as possible, from the *Nine-year Catalogue* now in course of active preparation.

Another important feature in the *Nautical Almanac* for 1880 is the substitution of Le Verrier's Tables of *Saturn* for those of Bouvard, which have been in use since 1834. The new Tables have been communicated by M. Le Verrier to the Superintendent, in anticipation of their publication. The tabular places of *Saturn*, as well as those of the Sun, *Mercury*, *Venus*, *Mars*, and *Jupiter*, are, therefore, now derived from Tables constructed by that astronomer.

## *Solar Physics.*

The quiescent state of the Sun during the past year has not been favourable to physical investigations, but, notwithstanding this, some interesting results have been obtained in this branch of astronomy. The Italian Spectroscopic Society* continues its work on the Solar prominences, and one of its most distinguished members, Professor Tacchini, has taken advantage of the lull in the activity of the Sun to discuss his observations of 1871 and 1873. A comparison of these two series shows that in 1873 the number of prominences had decreased to one-half of what it was in 1871, and that in both years twice as many were observed on the west limb as on the east. Further, there was in 1871 a preponderance in the northern hemisphere, whilst in 1873 the prominences were pretty equally divided between the northern and southern, with a rapid diminution in number, for both years, from the equator towards either pole. In the present year Professor Tacchini finds that the height of the chromosphere has not diminished much, and that the circulation of magnesium is as active as ever, though hydrogen prominences and metallic eruptions are now very rare. He further connects the absence of sodium in the chromosphere with the present paucity of Sun-spots, and considers it likely that this element may have a large share in their formation. The granules and faculæ appear now to be very marked, notwithstanding the absence of spots.

---

* *Memorie della Società degli Spettroscopisti Italiani.*

In partial opposition to this are Mr. Trouvelot's observations* on what he has called "veiled spots," from which he concludes—

"1. That during this year and especially during the interval from June 10 to August 18, and to a less degree to September 14, the chromosphere has been notably thinner than usual upon the entire surface of the Sun.

"2. That the granulations have been smaller and less numerous.

"3. That the light-grey coloured background seen between the granules has been more conspicuous and has occupied more space than usual.

"4. That there are spots which he has named 'veiled spots,' which are seen through the chromosphere which is spread over them like a veil.

"5. That these veiled spots are true openings of the photosphere, like those of the ordinary spots.

"6. That during this period these spots have been larger, darker, and more numerous than he has ever before seen them.

"7. That the veiled spots are scattered throughout all latitudes, though more complicated in the regions where the ordinary spots make their appearance.

"8. That he has observed spots at least within 10° of the north pole of the Sun.

"9. That the flocculent objects sometimes seen projected on the umbra and penumbra of spots are the remaining portion of the granulations composing the chromosphere, more or less dissolved by the forces emanating from the interior of the photosphere."

Professor Langley has continued his discussion of the question of the relative amount of radiation from the Solar photosphere, and from the umbra and penumbra of a spot respectively, and its bearing on the *direct* effect of Sun-spots on terrestrial climates. An interesting paper by him on the subject will be found in the *Monthly Notices* for last November, and it will therefore be sufficient to mention, in this connection, that his observations show the umbral radiation to be 54 per cent. and the penumbral 81 per cent. of the radiation from the same area of photosphere; from which he concludes that the greatest admissible *direct* effect of Sun-spots is to diminish the Solar radiation by a quantity somewhat less than 1-1000th and somewhat greater than 1-1100th part, giving for the limits of possible *direct* effect on terrestrial climate three-tenths and one-twentieth of one degree centigrade.

---

* *American Journal of Science and Arts*, No. 63, xi., March 1876.

A discussion has been made by M. Tisserand* of the observations of the Sun, taken by Carrington's method at the Toulouse Observatory in 1874 and 1875, the result being to show that either Carrington's or Spoerer's formula will satisfy the observations sufficiently well, though the motions of some of the individual spots are very erratic. M. Tisserand mentions particularly one which had such a rapidly increasing proper motion that after six days its daily motion was found to have decreased by one-tenth of its amount. Professor C. A. Young† has attacked the same question of the Sun's rotation, with the spectroscope, though rather with the object of verifying the principle of the displacement of lines in the spectrum, from the motions of the source of light, than with the idea of obtaining an accurate value of the period of rotation. From the relative displacement of the D and other lines at the east and west limbs respectively, he finds the equatoreal velocity to be 1·42 miles per second, while direct observation of Sun-spots gives 1·25. He is inclined to think that this discordance indicates a physical fact, and that the solar atmosphere really sweeps forward over the underlying surface in the same way that the equatoreal regions outstrip the other parts of the Sun's surface. This conclusion is opposed to the results of the Greenwich observations, which are in remarkably close agreement with the received value of the Sun's rotation.

Professor Young's observations were made with a fine diffraction grating by Mr. Rutherfurd, in which the spectra of the sixth and eighth orders were observed, the difficulty caused by overlapping in the spectra of the higher orders being obviated by the device of placing a prism in front of the object-glass of the viewing telescope, with its refracting edge perpendicular to the lines in the grating. The red of one spectrum is thus seen below the yellow of the next, which in turn is below the green of the succeeding spectrum, and so on. With this diffraction spectroscope Professor Young‡ has detected the duplicity of the 1474 line in the Solar spectrum, the two components being unequal. The coronal line corresponds to the stronger of the two, whilst the other is one of the faint lines in the spectrum of iron.

---

* *Comptes Rendus*, No. 14, lxxxii., April 3, 1876.

† *American Journal of Science and Arts*, No. 71, xii., November 1876.

‡ *American Journal of Science and Arts*, No. 66, xi., June 1876.

## *Discovery of Minor Planets.*

Thirteen minor planets have been discovered since the last Annual Meeting. Though considerably less than in the preceding twelve months, yet the number is far above the general average of yearly additions to the group. The names of the planets and their discoverers, and the dates and places of their discovery, are given in the following table:—

| No. | Name of Planet. | Discoverer. | Date of Discovery. | | Place of Discovery. |
|---|---|---|---|---|---|
| (160) | Una | C. H. F. Peters | 1876 | February 21 | Clinton, U.S. |
| (161) | Athor | J. Watson | | April 18 | Ann Arbor, U.S. |
| (162) | Laurentia | Prosper Henry | | April 21 | Paris. |
| (163) | Erigone | Perrotin | | April 26 | Toulouse. |
| (164) | Eva | Paul Henry | | July 12 | Paris. |
| (165) | Loreley | C. H. F. Peters | | August 10 | Clinton, U.S. |
| (166) | Rhodope | C. H. F. Peters | | August 17 | Clinton, U.S. |
| (167) | Urda | C. H. F. Peters | | August 29 | Clinton, U.S. |
| (168) | Sibylla | J. Watson | | September 28 | Ann Arbor, U.S. |
| (169) | Zelia | Prosper Henry | | September 28 | Paris. |
| (170) | | Perrotin | 1877 | January 10 | Toulouse. |
| (171) | | Borrelly | | January 13 | Marseilles. |
| (172) | | Borrelly | | February 5 | Marseilles. |

The following six minor planets, the discoveries of which were recorded in the two preceding Reports, have been named during the past year:—

| | | | |
|---|---|---|---|
| No. (139) | Juewa. | No. (150) | Nuwa. |
| „ (148) | Gallia. | „ (154) | Bertha. |
| „ (149) | Medusa. | „ (155) | Scylla. |

It is at length found impossible to continue the computation of the opposition ephemerides usually inserted in the *Berliner Jahrbuch* for all the small planets which come into opposition during the year. Space has only been found for fifty out of 125, which will be in opposition between January 1 and December 31, 1877. Most of the planets selected are of small magnitude, and the observations must, therefore, for the most part, be confined to those made with large equatoreals, for it is found to be waste of time to look for the smallest of these planets with the present

1877MNRAS..37..189.

meridional instruments. For this reason it is to be regretted that so few of the older and larger planets are not included in the selection. In 1877, though twenty-four brighter than the tenth magnitude are in opposition, only eight of them, including the four senior planets, have a daily ephemeris; and, consequently, sixteen of the brightest cannot be observed on the meridian during this year.

From an examination of the Table of opposition-magnitudes given for this year in the *Berliner Jahrbuch* for 1879, it will be seen that by taking the means of groups of twenty-five consecutive planets ranged in the Table in the order of their discovery, the lowest limit of magnitude has been, on the average, reached. In the Table, 125 opposition magnitudes are given. Forming these into five groups, the mean magnitudes are respectively 9·6, 11·0, 11·4, 11·4, and 11·3, and by subdividing the first group into two groups of ten and fifteen, the respective mean magnitudes are 8·7 and 10·1. It has also been found that when the same planets are ranged in the order of their mean distances from the Sun, the corresponding means bear a similar relation to each other.

## *Discovery of a New Comet.*

After an unusually long interval since the detection of a new comet, M. Borrelly discovered one at Marseilles, early in the morning of February 9, 1877, in the constellation *Ophiuchus*. Its observed position at $3^h$ $41^m$ A.M., mean time at Marseilles, was R.A. $17^h$ $13^m$, and N.P.D. 91° 17′. Its motion was rapid, increasing daily $44^m$ in R.A., and 3° 7′ towards the north. It had a bright and round nucleus about 3′·5 in diameter.* The last discovered comet of unknown period was detected by M. Borrelly, on December 6, 1874.

## *D'Arrest's Periodical Comet.*

In the *Comptes Rendus* (No. 9, Août 28, 1876), M. Leveau has given the final osculating elements of this interesting periodical comet, resulting from the investigation of which a brief abstract is given in the last Annual Report. This comet was discovered by M. D'Arrest, at Leipzig, on June 27, 1851, and will be in perihelion in May next. M. Leveau's investigation is based on the observations made at the former apparitions in 1851, 1857, and 1870, and he has previously published elements for the epoch 1869, October 13. By applying the perturbations produced by *Jupiter*, *Saturn*, and *Mars*, from this epoch to 1877, January 14, he has deduced the following corrected elements, from which a working ephemeris has been calculated for the convenience of observers at the approaching apparition. The new osculating elements are:—

---

* The announcement of the discovery of this comet was received by telegram from M. Stephan on the day of the Annual Meeting, in time to be inserted in this Report. The comet was independently observed by M. C. F. Pechüle, at Copenhagen, on the following morning.—E. D.

Epoch 1877, January 14·0, M.T. Paris.

$$\left.\begin{array}{lrrr} & {}^{\circ} & {}' & {}'' \\ \epsilon = & 301 & 56 & 54\cdot42 \\ \omega = & 319 & 9 & 14\cdot70 \\ \theta = & 146 & 9 & 27\cdot63 \\ \phi = & 15 & 43 & 9\cdot22 \end{array}\right\}\ \text{Mean Equinox and Ecliptic, 1880·0.}$$

$$\begin{array}{lrrr} \eta = & 38 & 53 & 18\cdot04 \\ n = & \multicolumn{3}{l}{540''\cdot41003} \end{array}$$

Perihelion passage, 1877, May 10·339, M.T. Paris.

The details of M. Leveau's investigations will be published in the *Annales de l'Observatoire de Paris*.

## *Santiago de Chile Observations.*

The observations made with the Meridian-Circle of the National Observatory at Santiago de Chile from 1856 to 1860, have lately been published under the superintendence of the former Director, Dr. C. W. Moesta, who had undertaken this duty since his return to Europe. They are contained in Vol. II. of the Santiago *Astronomical Observations*, and are given in the form of a catalogue consisting of 3,309 stars, mostly south of the equator. The reduction of the observations from apparent to mean place is given in detail for each star, and the mean Right Ascensions and north polar distances for 1860·0 for each separate observation. The results are, therefore, not so available for general use in this shape as they would have been if they were collected, the means taken, and then formed into an ordinary catalogue of stars. But from the orderly manner with which the separate results are arranged, there is not much difficulty in forming, if required, a mean result for the epoch 1860, January 1.

The volume also contains observations of the Moon and Moon-culminating stars from January 15, 1856, to December 30, 1857, and also some observations of *Mars*, *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, and of a few of the minor planets, made principally in 1856. The volume, which was printed at Dresden, concludes with a comparison of the Santiago Catalogue with those of Washington, Johnson, and Taylor.

## *Physical Observations of Saturn.*

Mr. Trouvelot* has during the last four years had many opportunities of examining the planet *Saturn*, using the 15-inch refractor of Harvard College, the great Washington refractor, of 26 inches aperture, and the 6-inch refractor of his own Observatory, and from the observations thus made he has drawn the following conclusions, A and B denoting the outer and inner divisions of the outer ring, and C the outer portion of the interior bright ring:—

"1. That the inner margin of the ring B limiting the outer border of the principal division, has shown on the ansæ some singular dark angular forms; which may be attributed to an irregular and jagged conformation of the inner border of the ring B, either permanent or temporary.

"2. That the surface of the rings A, B, C has shown a mottled or cloudy appearance on the ansæ during the last four years.

"3. That the thickness of the system of rings is increasing from the inner margin of the dusky ring to the outer border of the ring C, as proved by the form of the shadow of the planet thrown upon the rings.

"4. That the cloud-forms seen near the outer border of the ring C, attain different heights and change their relative position, either by the rotation of the rings upon an axis, or by some local cause; as indicated by the rapid changes in the indentation of the shadow of the planet.

"5. That the inner portion of the dusky ring disappears in the light of the planet at that part which is projected upon its disk.

"6. That the planet is less luminous near its limb than in the more central parts, the light diminishing gradually in approaching the border.

"7. That the dusky ring is not transparent throughout, contrary to all the observations made hitherto; and that it grows more dense as it recedes from the planet; so that, at about the middle of its width, the limb of the planet ceases entirely to be seen through it.

"8. And, finally, that the matter composing the dusky ring is agglomerated here and there into small masses, which almost totally prevent the light of the planet from reaching the eye of the observer."

Astronomers are much indebted to Mr. Marth for the continuation of his ephemerides of the satellites of *Saturn*. No observations have, however, been communicated to the Society during the year.

---

* *American Journal of Science and Arts*, No. 66, xi., June 1876.

1877MNRAS..37Q.192.

## *Observations of Jupiter's Satellites at Adelaide.*

Mr. Todd has employed his new 8-inch equatoreal, by Cooke, mounted in December 1874, in making a very valuable series of observations of the phenomena of *Jupiter's* satellites during the last opposition of the planet, extending from June 13 to October 15, 1876. He has recently forwarded to the Astronomer-Royal, for communication to the Society, a detailed statement of these observations, which consist of eclipses, occultations, and transits of the satellites, and also of the ingress and egress of the shadows. The local mean times of observation are given, as well as the corresponding Greenwich mean times, which are compared with the calculated times in the *Nautical Almanac*. Some notes on the physical appearance of the planet accompany the observations. A very interesting phenomenon observed more than once, independently, by Mr. Todd and by his assistant, Mr. Ringwood, occurred when a satellite was on the point of occultation. Instead of disappearing gradually behind the planet, it was apparently projected on the disk, as if viewed *through* the edge of the planet, supposing the latter were surrounded by a transparent atmosphere laden with clouds. This curious phenomenon was noticed on two occasions at the disappearance of the first satellite, when it was thus distinctly visible on, or through the edge of, the disk, for about two minutes before it was finally occulted.

Mr. Todd bears witness to the constantly varying aspect of the surface of *Jupiter*. He was much impressed with some sudden and extensive changes in the cloud-belts, as though a violent storm was raging, changing their appearance within an hour or two, or even less, not only in their form, but also in their magnitude.

## *Drawings of Jupiter.*

Considerable attention has been directed during the last few years to the apparent changes on the surface of *Jupiter*, and a large number of careful drawings have been made from time to time. Some of these have appeared in the *Monthly Notices*, including the two interesting series communicated by the Earl of Rosse and Mr. Knobel. Following a suggestion of Dr. Lohse, of Berlin, the Council appointed a Committee for the examination of all drawings forwarded to the Society. In reply to a circular issued by the Committee, drawings from widely separated places have been received, and these have been or will be sent to Dr. Lohse, a member of the Committee, who has undertaken the collation of them. Forty-two delineations of the planet have been received from Mr. Hirst, of Sydney, and also a series of 153 drawings from Mr. Trouvelot, of Washington. Others have been forwarded by Professor Tacchini, of Palermo, Mr. Todd, of Adelaide, and M. Lehardelay, of Fontenay-le-Marmion. These drawings all show that very rapid changes are still going on upon the surface of *Jupiter*, though the character of the equatoreal markings differ slightly from those shown upon the drawings of the planet made two or three years ago.

### *The Supposed Discovery of the Object perturbing the Motion of Procyon.*

In former reports allusion is made to the observations of an object supposed by M. Struve to be a companion to *Procyon*, and which seemed, from a comparison of his observations with the theory previously deduced by Dr. Auwers, to be the object causing the observed irregularities in the proper motion of this star. The image of this supposed satellite is now found by M. Struve to have been produced by an optical illusion on his part, and also by his assistant, Herr Lindemann.

As long ago as the year 1844, Bessel remarked that the proper motions of *Sirius* and *Procyon* were subject to irregularities, which he conjectured must be due to the attraction of bodies in their vicinity, either not perceptible to us, or which, at any rate, had not yet been discovered. It is not necessary to allude further to the case of *Sirius* at the present time; but as regards *Procyon* the matter was put into a definite shape by Dr. Auwers, who in the year 1861 made a careful investigation of all the available observations, and showed that it was possible to reconcile the whole by the hypothesis that the motion of the star was disturbed by the attraction of an unseen object, about 1″·2 distant, round which it moved in a plane perpendicular to the line of sight, and in a nearly circular orbit, in a period of about forty years. For some time before this M. Otto Struve had been examining the star with the Pulkowa refractor, continuing his scrutiny without result till the 19th of March 1873, when he detected a very faint point of light following the star at a very small distance, nearly in the same parallel. As the point of light was also seen by his assistant, Herr Lindemann, M. Struve was confirmed in his belief of the objective nature of the phenomenon. He was, however, desirous that the suspected object should be looked for at other observatories possessed of sufficient instrumental power. He communicated his wish immediately to Mr. Newall, requesting him to turn his Cooke's 25-inch refractor upon it, but unfortunately Mr. Newall was absent at the time, and daylight soon afterwards prevented further investigation till the next spring. Meanwhile Dr. Auwers repeated his theoretical investigation, and calculated what change the apparent position of the object ought to undergo in that time, supposing it to be really the disturbing cause of the proper motion of *Procyon.* The months of February and March 1874 were singularly unfavourable for astronomical observations owing to bad weather, but on the 9th of April and subsequent days the point of light was again seen, the observed position-angle corresponding with what Dr. Auwers had theoretically found that it should be.

Before these observations of M. Struve the star had been examined with the 26-inch refractor at the Washington Observatory, but without detecting a companion; however, on the 12th of November 1874, Mr. Alvan Clark thought he saw a small object in a different position from that seen by M. Struve, and on November 25 and 26 of the same year Professor Holden saw another object within 10″ of *Procyon*, and also at a different position-angle from that seen at Pulkowa. On January 12, 1876, he and Professor Watson both saw this, and also two other faint points of light, all less than 10″ from the star, and at different position-angles, both with respect to each other, and also to that announced by M. Struve. Professor Holden suspected a still fainter companion between one of these and *Procyon.* These additional observations induced M. Struve to re-examine the subject with great care, the result of which has been to convince him that the phenomenon he had seen had no objective existence, but was the effect of an optical illusion which causes him (and Herr Lindemann also) to see under certain circumstances a faint image, or point of light, at about 10″ distance from a bright star, and nearly in a horizontal line with it. On the 17th and 18th of April 1876, he found this to be the case with the bright stars *Regulus* and *Capella.* On the 11th of the following month, both he and Herr Lindemann observed a similar point of light near *Arcturus*, which, however, they were unable to perceive again on the following night.

M. Struve intends to make some further experiments on the subject, as a warning against a species of optical illusion which has not hitherto received much attention. It is a very singular circumstance that the different position of *Procyon* in the telescope with respect to a vertical circle seems to have produced that apparent change of position-angle in the supposed satellite which, from its agreement with the theoretical investigation of Dr. Auwers, led M. Struve so strongly to believe that he had detected the body whose attraction was producing the observed variability in the proper motion of *Procyon.*

It is certainly more pleasing to record the confirmation of a supposed discovery than its withdrawal; yet the latter has occasionally to be done, as in the case of the unconfirmed satellites of *Uranus*, generally believed to have been seen by Sir W. Herschel, until disproved by modern observations. The present instance is interesting as showing the close scrutiny to which any astronomical observation is now subjected by the aid of other instruments of equal or greater power, and the consequent improbability of anything not really objective being long supposed to be so.

1877MNRAS..37Q.195.

## *Photographs of Spectra of Stars.*

In an oral communication to the Society at the December meeting, giving the substance of a paper presented to the Royal Society, our President, Dr. Huggins, gave an account of the important results he had obtained in the application of photography to the spectra of stars, a work which he first took up in conjunction with Dr. Miller in the year 1863. Dr. Huggins has obtained successful photographs of the spectra of *Sirius*, *Vega*, *Venus*, and the Moon, with comparison spectra of the Sun, taken the next morning on the same plate. The spectrum of *Vega* in particular shows seven strong lines in the ultra-violet extending from G to M of the Solar spectrum, and these are so well defined as to allow of accurate micrometric measurement. Dr. Draper has also for some time past been engaged on the same work, and has obtained photographs of *Vega* and *Altair*, showing bands or broad lines in the violet and ultra-violet regions, unlike anything in the Solar spectrum. He has also taken photographs of the spectrum of *Venus*, which show a weakening towards H and above that line of the same character as that which he has photographically observed to take place in the spectrum of the Sun near sunset.

## *New Double Stars.*

A catalogue of fifty new double stars, discovered with the 11-inch refractor of the Cincinnati Observatory, has been circulated by Mr. Ormond Stone, the Director. It has been prepared by Mr. H. A. Howe, who has arranged the matter in a tabular and convenient form for reference, exhibiting the approximate R.A. and N.P.D. for 1880, with the precessions in both elements; the estimated position-angles, distances, and magnitudes of the components; and the date of the discovery of the duplicity of the star. The stars are included between 8° and 40° south declination, and the angular distances vary from less than one second to eight seconds of arc. The greater number of the stars are of small magnitude, averaging 8 and 10 for the two objects. A few of the principal components are of the sixth magnitude, while the smallest are registered as of the eleventh.

Mr. Burnham has continued his examination of the heavens with the view of detecting close double stars not before identified. How he has succeeded in this interesting field of research can be gathered from the catalogues of new objects the duplicity of which has been first noticed by him. These have appeared in various publications—first, in our own *Monthly Notices*, and subsequently in the *Astronomische Nachrichten* and the *American Journal of Science and Arts*. It would have been more convenient to those who are in the habit of referring to previous results of double-star observations if a continuous series of catalogues, such as those of Mr. Burnham, had appeared from time to time in the same publication; and as the commencing catalogues of his series of measures are inserted in the *Monthly Notices*, some regret has been expressed that all of them had not been communicated to the Society.

From the large number of hitherto unknown double stars discovered by Mr. Burnham and other recent observers, it may be concluded that as their attention is now directed to the smaller classes of stars, it will be found that, like the minor planets, an almost inexhaustible field of discovery is open to any one having a good eye and a sufficiently powerful instrument. It is, however, important in the case of suspected binaries, that the angular positions and distances should be instrumentally measured, if possible, as mere estimated data should not be considered sufficiently accurate as the basis for any future determination of their orbits.

## *Micrometric Measures of Double Stars.*

M. Dunér has recently published an important series of observations of double stars made at the Lund Observatory in the years 1867 to 1875, in the course of which nearly 2,700 observations have been obtained of some 600 stars selected chiefly from W. Struve's catalogue. The measures were made with a filar micrometer applied to a Fraunhofer equatoreal of 245 millimetres (about 9½ inches) aperture, and 4·31 metres (about 14 feet) in focal length, and the periodic errors of the screw were carefully determined in 1876 at the end of the series of observations. Besides his own measures of distance and position-angle, M. Dunér has collated, under the head of Notes, at the end of the volume, the principal results obtained by previous observers, and has exhibited, in a tabular form, the changes which appear to have taken place, as shown by discordances from the mean. In a final table, a classification of the stars, according to the amount of relative motion of the components, is given, the largest class being that containing double stars which have not as yet changed their relative position. M. Dunér is still continuing his work on double stars, to which he hopes to be able to devote a much larger portion of his time than has been possible in the period to which these observations refer.

The following table, according to M. Dunér, shows the distribution of stars, with reference to their relative motion, since the date of the first observations:—

| Class. | Motion. | Number of Stars. |
|---|---|---|
| | ° | |
| I. | 360 | 8 |
| II. | 180 | 8 |
| III. | 90 | 8 |
| IV. | 30 | 16 |
| V. | 10 | 46 |
| VI. | Certain | 55 |
| VII. | Probable | 51 |
| VIII. | Insensible as yet | 207 |
| IX. | Nil, no physical connexion | 11 |

A memoir by Mr. Knott, containing nearly 2,000 observations of about eighty selected double stars, has been lately communicated to the Society, and will be published in the *Memoirs*. In this careful work Mr. Knott has followed the excellent model of the *Celestial Cycle*, accompanying his results by descriptive and critical notes, in which (as also in M. Dunér's volume) particular attention is paid to the colour and magnitude of the components.

## *Doberck's New Elements of the Orbit of ω Leonis.*

In a paper read before the Royal Irish Academy in April last, Dr. Doberck has given the result of his recent investigation of the orbit of *ω Leonis*, in which he has discussed with great completeness all the data at his disposal up to 1876. This star, one of the most remarkable of the double stars discovered by Sir W. Herschel, has occupied the attention of most of our double-star observers since its discovery, but its excessive closeness has made it a very difficult object to measure. For this reason, very great discrepancies are found in the observations, especially when they have been attempted with small telescopes. Notwithstanding these difficulties, the star has been carefully watched during the last fifty years, or from the time when W. Struve commenced his observations at Dorpat. The notes of the appearance of the two stars recorded by the different observers are very conflicting, for while Sir James South, in 1826, states that the components are of the sixth and ninth magnitudes, the small star being pale blue, W. Struve, about the same time, remarks that they differ but little in magnitude and are both yellow, the smaller being certainly of the deeper colour. On the other hand, M. Dembowski has more recently made them white. The change in the relative distances between the stars was noticed by Sir W. Herschel, who made notes in 1782 and 1783, that the distance between them was increasing;

in 1795, that they were half a diameter of the smaller star asunder; and in 1804, that the space between them was nearly a diameter of the smaller one. It was seen oblong by W. Struve, in 1836 and 1838, and single by Mädler in 1843. Winnecke, in 1858, and Engelmann, in 1865, were unable to separate the two objects.

Elements of the orbit have been calculated on several occasions, but no one has paid greater attention to this star than Professor Klinkerfues, of Göttingen. But the great difficulty experienced in obtaining accurate measures has created corresponding difficulties in the calculation of the orbit. A first investigation of Klinkerfues appeared in 1855 (*Ast. Nach.* No. 990); these were followed in 1858 by a second and revised system of elements (*Ast. Nach.* No. 1,127), both of which were intended to illustrate his method of determining the orbit of a binary star; and, lastly, in his *Theoretische Astronomie*, he has published a third series of elements determined on twelve annual means of measures made to 1867, by Herschel, W. Struve, Mädler, Secchi, and Engelmann. In determining these last elements, Professor Klinkerfues considered that he had used all the available measures, but Dr. Doberck points out that many additional measures had been made at the time, though many of them have only recently been published.

That the elements calculated by Professor Klinkerfues were imperfect, and required considerable modification to satisfy the observations, was very evident to those interested in the subject, as may be seen from the following remarks of M. Otto Struve: "The elements of the orbit of $\omega$ *Leonis*, calculated by M. Klinkerfues, in 1858, are still very defective. For 1870 his ephemeris indicates the distance as $1''\cdot06$, and the direction as $10^\circ\cdot9$, while our measures give respectively $0''\cdot58$ and $52^\circ$. Probably the erroneous result of his calculations should be attributed chiefly to the uncertainty of M. Mädler's measures, which were employed to form the last normal place for 1853. Without doubt the period of revolution will turn out to be much shorter than that found by M. Klinkerfues."

Dr. Doberck, at the commencement of his investigation, selected the angles and distances observed by O. Struve, to form his interpolating curves, and thus construct an ellipse. He found all the points well represented, but the principal star was not included in the circumference, and he was not able to alter the curve in a justifiable manner, so as to get the star inside the ellipse. He "considered it therefore not unlikely that O. Struve's measures, though as accordant among themselves as could be expected from the large refractor, were perhaps not quite free from systematic errors, though corrections had been applied as deduced from observations of artificial double-stars." By this system of interpolating curves applied to all the observed angles and distances, and by varying them when required to satisfy the observations, Dr. Doberck has determined five different sets of elements, of which the following are the last and definitive values:

| | ° ′ |
|---|---|
| Node ... ... | 148 46 |
| $\gamma$ ... ... | 64 5 |
| $\lambda$ ... ... | 121 4 |
| $e$ ... ... | 0·536 |
| P ... ... | 110·82 years |
| T ... ... | 1841·81 |
| $a$ ... ... | 0″·890 |

A comparison of the observed angles of position and distances, with those deduced from the preceding elements, is given, including all the known observations from 1782 to 1876. The residual errors appear small, and good evidence is shown that the measures are represented more closely by Dr. Doberck's new elements than by any of those previously published.

## *Dun Echt Observatory Publications.*

Double-star observers will be thankful to Lord Lindsay for the publication of the first volume of the Dun Echt Observatory publications, which contains a summary or index of all the measurements of double stars included in W. Struve's *Mensuræ Micrometricæ* and appendices. The scarcity of the original volume, which is rarely found in the libraries of amateur observers, together with its inconvenient size, has induced Lord Lindsay to commence his series of publications with this very valuable and useful abstract, in which most of the information relating to Struve's measures is given. The compilation and arrangement of the catalogue, and the reduction for bringing up the epoch to 1875, have been performed by Dr. R. Copeland.

The separate columns of the catalogue contain the R.A. and declination for 1875; the lowest and highest powers used by Struve; the mean date of observation; the mean distance and position-angle as deduced by Struve; and the magnitudes and colours of the components; the latter translated from the Latin names. These translations of the colours were carefully considered, and then strictly adhered to. A table of the precessions in declination for ten years is also appended; and a diagram is given, from which the variable part of the precession in R. A. for ten years in minutes of time can be taken. The work is printed in quarto form, and has been most liberally distributed by Lord Lindsay among astronomers and scientific institutions.

## *The New Star in Cygnus.*

A remarkable stellar outburst, similar to that which appeared in *Corona Borealis* in May 1866, was first noticed by Dr. Schmidt, at Athens, on the 24th of November last, at 5.41 P.M., in the constellation *Cygnus*, then near the zenith. The new star, when first observed, was of the third magnitude, and of a yellow colour, near $\rho$ *Cygni*, where Dr. Schmidt is sure that no corresponding object existed on the evening of November 20. The sky was overcast at Athens on the three following days, and most probably the outburst appeared at its full brilliancy in the interval between November 20 and 24. At midnight on the latter day the light of the star was of greater intensity than that of $\eta$ *Pegasi*, noted of the third magnitude by Argelander. Its position does not appear to be recorded in the usual catalogues of small stars; certainly not in those of Lalande, Weisse's Bessel, Bode, D'Agelet, or in the *Durchmusterung* of Argelander. From an observation made by Mr. Hind at Mr. Bishop's Observatory on December 13, its R.A. for 1876·0 is $21^{h}\ 36^{m}\ 50^{s}\cdot41$., and its N.P.D. $47^{\circ}\ 43'\ 21''\cdot5$.

Unfortunately, Dr. Schmidt's discovery was not immediately communicated to the Astronomer-Royal or to any other English astronomer, although a telegram was sent to Dr. Littrow, at Vienna, and probably to other Continental observers. The first information of the sudden appearance of the new star was only received in England in the second week in December, from the public notices inserted in the *Bulletin International* and *Comptes Rendus*. This neglect is much to be regretted, as there were eight favourable evenings at Greenwich before December 9, when spectroscopic observations might have been successfully made, and of these at least two were near the time of the star's maximum brilliancy. Principally for this reason, but also in consequence of almost continuous unfavourable weather afterwards, very few observations of the star have been made in this country. When seen by Mr. Hind on December 13, it had receded to the sixth magnitude, and was without a trace of colour. The observers in Paris were more fortunate in obtaining information, for the star was examined on December 2, during a brief interval of clear sky, by MM. Henry, Cornu, and Cazin, and estimated of the fifth magnitude. Under more favourable circumstances, on December 4, M. Cornu made some satisfactory observations of the spectrum of the star with the eastern equatoreal of the Paris Observatory, the magnitude on that day being estimated at 4-5. The spectrum exhibited eight detached bright lines on a luminous ground, with an almost complete interruption of the light between the green and the indigo. M. Cornu saw no dark lines; if they had existed they must have been very fine, and invisible owing to the faintness of the light.

Naming the bright lines according to their intensity by the

Greek letters $\alpha$ to $\theta$, their positions in the spectrum, in relation to those of certain elements, may be readily seen from the numbers in the following table determined by M. Cornu :—

| | $\alpha$ | $\delta$ | $\gamma$ | $\beta$ | $\zeta$ | $\eta$ | $\theta$ | $\epsilon$ |
|---|---|---|---|---|---|---|---|---|
| Observed | 661 | 588 | 531 | 517 | 500 | 483 | 451 | 435 |
| Hydrogen | 656 (C) | ... | ... | ... | ... | 486 (F) | ... | 434 |
| Sodium | ... | 589 (D) | ... | ... | ... | ... | ... | ... |
| Magnesium | ... | ... | ... | 517<br>(*b* mean) | ... | ... | ... | ... |
| Coronal line | ... | ... | 532 | ... | ... | ... | ... | ... |
| Chromosphere lines. | ... | 587 | ... | ... | ... | ... | 447 | ... |

M. Cornu remarks as an interesting fact, but one requiring confirmation, that there are several coincidences shown in the preceding table which have led him to the conclusion that the bright lines in the star-spectrum correspond exclusively with the principal lines in that of the chromosphere, and therefore that the light of the star possesses precisely the same composition as that of the Solar envelope. He says: "But the most curious result, which I give here with much reserve, but which it will be very interesting afterwards to verify, is the coincidence of the line $\gamma$, very bright in the spectrum of the star, with the green line $\lambda = 532$ (1474 of Kirchhoff's scale), observed in the spectrum of the Solar corona and in the chromosphere; the feeble band $\theta$ corresponds also with a band $\lambda = 447$ of the chromosphere; one is thus led to think that the line $\delta$ corresponds rather with the bright line of the chromosphere $\lambda = 587$ (helium), than with that of sodium, 589. If this interpretation be correct, the bright lines of the spectrum of the star comprehend exclusively the brightest and the most frequent lines of the chromosphere."

The spectrum of the star has also been examined by Padre Secchi, Dr. Vogel, and others, all of whom confirm generally the previous observations of M. Cornu. Several bright lines were seen by Dr. Vogel in the red, blue-green, and blue parts of the spectrum; bright bands were also visible in the yellow and green; but these may possibly be portions of a continuous spectrum seen bright by contrast with absorption bands, of which there were as many as eight or ten. The blue and violet were brighter than in most stars with band spectra. The bright lines C, F, and $D_3$ were visible; *b*, however, was probably not seen bright, but a bright line on the blue side was noticed, which may possibly be identical with a line which under peculiar circumstances is the brightest in the spectrum of hydrocarbon. One seen in the violet may be the third line of hydrogen. Dr. Vogel remarks that there are three other stars in *Cygnus* giving quite unique spectra.

By careful comparisons with several neighbouring stars, Dr. Schmidt noted the gradual diminution in the intensity of the light of the star almost daily. The variations of magnitude are exhibited in the following table:—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| November | 24 | 3·0 | Magnitude. | December | 5 | 5·9 | Magnitude. |
| ,, | 25 | 3·1 | ,, | ,, | 7 | 6·3 | ,, |
| ,, | 26 | 3·1 | ,, | ,, | 8 | 6·5 | ,, |
| ,, | 27 | 3·2 | ,, | ,, | 9 | 6·6 | ,, |
| ,, | 28 | 3·8 | ,, | ,, | 10 | 6·5 | ,, |
| ,, | 29 | 4·7 | ,, | ,, | 11 | 6·7 | ,, |
| ,, | 30 | 5·0 | ,, | ,, | 12 | 6·7 | ,, |
| December | 1 | 5·2 | ,, | ,, | 13 | 6·8 | ,, |
| ,, | 2 | 5·4 | ,, | ,, | 14 | 6·9 | ,, |
| ,, | 3 | 5·6 | ,, | ,, | 15 | 7·0 | ,, |
| ,, | 4 | 5·8 | ,, | | | | |

At the end of the year the star was still about the seventh magnitude, and of a decidedly orange colour, with a reddish tint.

### *Suspected Changes in Nebula Messier, No.* 17 (*the Horseshoe Nebula*).

Professor Holden has made a very interesting comparison of all the available drawings of the well-known nebula Messier, No. 17,* with the object of ascertaining whether any visible changes could be detected in the relative positions of the nebula and neighbouring stars. The drawings are those of Sir John Herschel made in 1833 and 1837 with his 20-foot reflector of 18½ inches aperture; of Lamont (1837) with the 11-inch Munich refractor; of Mason (1839) with a 14-foot reflector of 12 inches; of Lassell (1862) with his 4-foot reflector at Malta; Trouvelot (1875) with a 6½-inch Merz refractor; and Trouvelot and Holden jointly (1875), with the 26-inch refractor of the Naval Observatory at Washington.

To examine the question as to the motion of the nebula relative to the stars, Professor Holden has divided the drawings into three groups, the *first* consisting of those made before 1840; the *second*, of Lassell's beautiful delineation, to which a great weight is given; and the *third* of the two drawings made in 1875, one at Cambridge, U.S., and the other at Washington. To prove the existence of a change, he has considered it necessary and sufficient to show that there has been an alteration in the position of some prominent feature, such as the "horseshoe," in the interval between the epoch of the first group and the second; and that this apparent change is confirmed and continued in the two drawings of 1875, greater weight being given to that obtained with the larger instrument. Professor Holden remarks: "It must be remembered that with two instruments of *equal light*, hardly more discrepancy in the positions of the *brighter* portions of the nebula is to be expected than in the star-positions, for these positions are determined by the stars themselves, and can be assigned with almost no error in a nebula which contains so many stars as the one under consideration. The fainter portions may vary greatly from the smaller to the larger instruments." Tables are given by Mr. Holden containing a comparison of the relative positions of the stars as laid down in the different drawings, which, on the whole, fairly agree; and in another table he has exhibited, in a convenient form, the evidence for or against a notion of the "horseshoe," with reference to its contained stars. As a final result of the comparison, he concludes that the tables show that the stars have remained in their relative positions from 1837 to 1875, and that "the drawings, whether taken as a whole or considered according to their relative importance, show that the 'horseshoe' has moved with reference to the stars, while the *Messierian* streak has not moved; and that, therefore, we have evidences of a change going on in this nebula. This may be a veritable change in the structure of the nebula itself, such as was suspected by Schroeter, confirmed by O. Struve, and again confirmed by myself in the nebula of *Orion*; or it may be the bodily shifting of the whole nebula in space, in some plane inclined to the line of sight."

---

* *American Journal of Science and Arts*, No. 65, xi., May 1876.

Comparisons of other well-defined nebulæ, on a similar plan to that adopted by Mr. Holden, would probably give us much information respecting the proper motions of different portions of nebulæ. The difficulty of making accurate delineations of such delicate objects must, however, make us cautious in accepting any apparent changes in the position of nebulæ in relation to neighbouring stars, unless they are confirmed by drawings of more than one observer at the beginning and end of each interval of time.

As bearing on this subject, it may be mentioned that a well-executed drawing of the nebula in *Orion*, reduced from a larger delineation, has been presented to the Society by Signor Tempel, of the Arcetri Observatory, near Florence. It is a valuable addition to the other representations of the same nebula already in the possession of this Society.

### *Montigny's Researches on Scintillation.*

The Council have already noticed in a previous report the important researches of M. Montigny on the scintillation of the stars. In a paper contained in the "*Bulletins de l'Académie Royale de*

*Belgique*" (2me série, t. xlii., No. 8, Août 1876), M. Montigny has given an abstract of the results recently obtained by him from some further investigations on the same subject, especially in relation to the connection of the intensity of the scintillations with the variations in the conditions of atmospheric phenomena. This very interesting astro-meteorological question has occupied the attention of M. Montigny for several years past, the observations discussed in the present paper extending from October 1870 to August 1876. They were continued, with occasional interruptions, during this interval as often as the state of the weather permitted, and under the influence of varying conditions of the atmosphere, and of a different temperature, which in December 1870 and January 1871 and 1876 was as low as −9° and −10° centigrade.

The instrument employed was an astronomical telescope of 77 millimetres aperture, with a magnifying power of 85. A scintillometer, formed of a circular plate of thick glass, was mounted obliquely in the tube of the telescope, in front of the eye-piece, and having a circular motion by means of a contrivance placed outside the telescope, by which the exact number of revolutions which the plate makes in a second of time can be ascertained. By this arrangement the image of any star towards which the telescope may be directed describes a perfect circumference in the field of the instrument. When there is no scintillation, the circle forms a continuous line presenting the general tint of the star, but when it is visible, this circular curve is broken into coloured arcs, varying rapidly, among which may ordinarily be detected red, orange, yellow, green, blue, and occasionally violet, according to the character of the scintillation. By means of a micrometer-wire placed in the focus of the telescope, the number of coloured arcs contained in the curve described by the stellar image is obtained and the amount of intensity determined. About seventy stars were selected for the experiments, varying from the first to the fourth magnitudes, and they are included in the three principal types, according to Padre Secchi's classification. The stars observed on each evening were those situated in the eastern and western portions of the heavens, and owing to the continuity of the observations this method of selection had the effect of obtaining results for each star, when situated in opposite quarters of the sky, at intervals of several months.

M. Montigny gives a series of tables of comparison between the intensities of scintillation and different meteorological data, determined from observations made at the Observatory of Brussels. The tables exhibit the intensities ranged in order of the seasons, of single rainy days, of consecutive rainy days, of days of high wind and storms, etc., leaving a comparison of other data in relation to the temperature of the air, atmospheric pressure, and some other phenomena, for another paper. Important results are shown in these comparison tables; among them it may be noticed that in some seasons it was found that the intensity of scintillation is decidedly greater in rainy than in dry weather, and more marked in winter than in summer, about equal in spring and autumn in dry weather, but in general wet seasons the intensity is greater in spring than in autumn. On stormy nights the scintillation increases or diminishes in intensity with the rise and fall of the barometer, being greatest on the approach of a storm, and again diminishing as it passes away. Other facts have been satisfactorily brought out, but these are sufficient to show that most interesting results have been obtained by M. Montigny from his systematic series of observations.

## *Progress of Meteoric Astronomy during the year* 1876.

The records of meteoric phenomena during the past year comprise a few falls of aërolites, the occasional appearances of several considerable fireballs, and a few observations relating to periodical star showers, and to radiant points of meteor showers occurring with less intensity on ordinary nights of the year.

Of meteorites whose fall was witnessed, and specimens of which have been preserved, the following brief list supplies the localities and dates, and some of the particular characters of the aërolitic falls :—

| Date. | Local M.T. | Locality, and Remarks. |
|---|---|---|
| 1875, Sept. 14 | $4^h$ p.m. | Supino, Circ. Frosinone, Italy (Stone fall). |
| 1876, April 20 | $3^h\ 40^m$ p.m. | Rowton, near Wellington, Salop, England (Iron-fall, $7\frac{3}{4}$ lbs.). |
| 1876, June 28 | $11^h$–$12^h$ a.m. | Ställdalen, Dalecarlia, Sweden. Three or four stones fell—the largest $4\frac{1}{4}$ lbs. |

Aërolitic falls of less importance, or of which the occurrences are less authentically reported, have also taken place on the following dates :—

| Date. | Local M.T. | Locality, and Remarks. |
|---|---|---|
| 1876, June 25 | $9^h$–$10^h$ a.m. | Kansas City, Missouri, U.S.A. No meteor seen; but a small stone, weighing a few ounces, fell—too hot to be touched immediately—on the tin roof of a house, which it almost penetrated, and bounded off.* |
| 1876, July 8 | $4^h$ a.m. | Louisville, Kentucky. A stone fell, accompanied by a report, in the streets of the town, weighing about 2 lbs.† |

---

* *Amer. Journ. of Science*, vol. xii., p. 316; October 1876.

† *Louisville Courier Journal* (*Scientific American*, of Aug. 12, 1876, p. 98). A large meteor (*see* below, p. 211) was seen on the same date in Indiana.

| Date. | Local M.T. | Locality, and Remarks. |
|---|---|---|
| 1876, Oct. 19 | 2$^h$ a.m. | Newburyport (Mass.) and Ledyard (Conn), U.S.A. A large fireball seen at the former place; and numerous meteoric stones were found at the latter place on the day following its appearance.* |

Among these meteorites, the Rowton aërosiderite is particularly interesting, as it is only the seventh example of a solid iron meteorite whose descent has been witnessed, and of which a specimen has been preserved. It fell in rainy weather, unaccompanied by any visible fireball, but preceded by two startling detonations heard northward from the Wrekin over the neighbouring villages of Shropshire for many miles. It penetrated the soil of a turf-field to a depth of eighteen inches, almost vertically, but with a slight inclination (from the north-west towards south-east), and when discovered about an hour after the occurrence it was still quite warm. It was presented to the British Museum by his Grace the Duke of Cleveland, in whose property it fell; and a cast of the meteorite may be compared with similar casts of the iron meteorites of Braunau, Victoria West (S. Africa), Nidigullam (Madras), Marysville, and Charlotte (Dickson Co.), U.S.A., of which, with that of Agram, in Croatia, the actual falls have previously been witnessed. The meteorite itself is undergoing section and preparation for an analytical examination of its composition. The stone-fall at Supino, in Italy, on September 14, 1875, happened on the same day as the appearance of the large detonating fireball in England described in last year's Report (*Monthly Notices*, vol. xxxvi., p. 216), and the coincidence appears to be particularly deserving of attention, as it was stated in the *Bradford Times* (*Nature*, September 23, 1875), that the detonation which followed the meteor's appearance at that place was so loud as to be plainly heard indoors by those who had not seen the meteor, which more clearly established its aërolitic character than had been suspected in last year's Report. The coincidence of a stone-fall on the same date, if not purely accidental, raises a reasonable conjecture that it may have belonged (with the aërolitic fireball simultaneously observed) to a shower of ordinary shooting stars whose approximately known radiant point was found to agree exactly with the true course or direction of flight of the detonating meteor; for it will be remembered that a comparison of many well-accordant descriptions of its apparent path extensively observed in England enabled the true direction and the real path of the large fireball of September 14, 1875, to be determined with more than ordinary certainty and precision.

---

* *New York Observer*, Thursday, Nov. 9, 1876. The asserted fall of a small stone, apparently meteoric, stated in *Nature*, vol. xv., p. 305, to have been observed at Ecclesfechan, near Glasgow, on the evening of Jan. 2, 1877, may be added to the above list of supposed falls of aërolites recently recorded.

The fireballs of large size which have been recorded during the past year may be briefly noticed here under three separate descriptions. Among the first, or detonating class, the following appear to have been the most conspicuous examples :—

| Date. | Wash. M.T. | Locality, and Remarks. |
|---|---|---|
| 1875, Dec. 27 | $9^h$–$9^h\ 20^m$ p.m. | Kansas, Missouri, and Iowa States, U.S. A large fireball bursting into many fragments, and leaving a luminous smoke-track, visible for $15^m$, commenced its course over Nebraska, 120 miles west of Missouri R., and exploded, with heavy detonations, over Missouri State. Real motion due eastward, with a steep inclination towards the Earth. |
| 1876, Jan. 5 | $10^h\ 30^m$ p.m. | Iowa and Missouri, U.S. A large and brilliant fireball, exploding with many thunder-like reports. Its true course was nearly vertically downwards from north-west towards south-east. |
| 1876, Jan. 31 | $5^h\ 30^m$ p.m. | Louisville, Kentucky, and Tennessee, U.S. A large fireball observed by Dr. Lawrence Smith; said by some observers to have been followed by sounds of an explosion. |
| | Local M.T. | |
| 1876, June 15 | $8^h\ 10^m$ p.m. | Suez to Port Saïd. A large fireball, which burst with a very loud explosion, illuminating the sky brightly at all the stations on the Maritime Canal; moving from west to east, or from south to north, vertically over the *Déversoir*, and leaving a light streak there at the point where it exploded. |

A large fireball which was perhaps also detonating (*see* below, p. 211) was observed in France at about $9^h$ p.m., on November 5, 1876. In the second class of fireballs may be included those which have been sufficiently observed in England to afford means of determining, at least approximately, the real height and position of their tracks, and the real direction or apparent radiant-point from which they took their flight. The following list comprises all the comparisons of this kind which have been obtained from the best available descriptions, and it relates in general to those fireballs which have been most generally observed in England during the past year :—

| 1876, Date and Hour, G.M.T. Size and General Appearance. | Places of Observation (available for calculation). | Meteor's Real Course (distances in B. S. Miles). | | | |
|---|---|---|---|---|---|
| | | Beginning: Height and Locality. | End: Height and Locality. | Radiant-point, observed. $\alpha$ $\delta$ | Nearest known Radiant-point. $\alpha$ $\delta$ |
| July 25, 10$^h$ 5$^m$ p.m. Head 15′ × 30′; green or blue, with long tail of red sparks; left no streak. (London and S. of England.) | Poplar (London) and Street (Somerset); corroborated by Hersham (Surrey) and Maidenhead (Berks). An observation at Brighton describes the meteor's path as so strongly inflected at the middle as to be wholly unconformable in the first half, although agreeing well with these accounts in the last half of its flight. | 62 miles over W. pt. of Guernsey (commenced as a small shooting star 90 miles over Brittany, in France, by Poplar observation of its initial point). | 27 miles over Crickdale (Wilts), near Cirencester; length of path 107 miles in "5 or 6" (Street), or (?) nearly 200 miles in "about 6 secs." (Poplar observation.) | 258° − 24° (near *Antares*). From the Poplar and Somersetshire observations. | 258° − 20° July; $O_2$, Neumayer.<br>245° − 30° July; Schmidt.<br>262° − 33° July 23; ☄ 568 II. Ω.<br>250° − 35° Aug.; $\Lambda_5$, Neumayer.<br>266° − 42° Aug.; Schmidt.<br>259° − 36° Aug. 5; ☄ 568 II. ☋. |
| Aug. 11, 11$^h$ 22$^m$ p.m. Bright as the full Moon; left a streak for 1 m., 10° long at Cardiff, curving at last like a sickle (Crediton, Devon). | Radcliffe Obs., Oxford, with Crediton and Sunderland; corroborations at Clifton, and Writtle (Essex). | 73 (± 8) miles over a point 9 miles W. of Ludlow, Salop. | 45 (± 5) miles over a point midway between Neath and Llandovery (Caermarthen, S. Wales). | 60° + 51° (± 2°) (near λ *Persei*) | An erratic *Perseïd*. Length of path, 58 miles in "1 second" (Oxford). |
| Aug. 13, 9$^h$ 27$^m$ p.m. About as bright as *Venus*; left a streak for 5 or 6 secs. | Buntingford (Herts), Folkestone, and Radcliffe Obs., Oxford; the last for point of first appearance only. | 90 miles over Walton (near E. Dereham, Norfolk). | 40 (± 4) miles over Potters Bar, between London and Hertford. | 39° + 66° (± 2°) (near ι *Cassiopeiæ*). | Erratic *Perseïd*. Length of path and height at commencement uncertain; about 82 m. in "2 seconds" (Buntingford). |

| | | | | | |
|---|---|---|---|---|---|
| Aug. 15, 9ʰ 30ᵐ p.m. A fine fireball; yellow to blue or green, with long train, and some white streak remaining. Brilliant over Wales and Ireland; long, slow path; no terminal explosion. | Radcliffe Obs., Oxford, and Newton St. Loe (Bristol); corroborated at Newtown (Wales). [Douglas, Isle of Man, and Cookstown, Tyrone, Ireland, for prolongation of its course.] | 69 miles over a point 10 miles W. of Gresholm Isle, Saint Bride's Bay (South Wales). | 34 miles over a point 15 miles W. of Arklow (Ireland). 75 miles in "9 secs." (Newtown; 20 or 30 secs., Bath.) [By Irish and Manx descriptions pursued its course to 15 miles above the centre of Ireland, near Mullingar. Path about 130 miles?] | 310° − 10° (± 8°) (near $\mu$, $\epsilon$ *Aquarii*). | The apparent paths much superposed, and radiant-point only linearly defined from $\delta$ *Aquarii* to $\frac{1}{2}$ ($\theta\lambda$) *Antinoï*; the adopted radiant is the middle point of this line. |
| Sep. 24, 6ʰ 30ᵐ p.m. Two maxima, the last much brighter than full ☽; streak on last part 16 min.; white, globular, no sparks. Seen at Hull, and in Paris. Illumination over the English Channel most intense. | Orwell Park Obs. (Ipswich); St. Pierre (Dunkirk Railway), Broadstairs, Deal, Great Marlow, Dymock, (Hereford), and other generally corroborating descriptions. | 58 miles over a point between Ostend and Bruges (highest observed altitude; length of path 45 miles in "3 secs." Orwell Park Observatory). | 16 miles over a point 15 miles N. of Ostend. | 285° + 35° (± 5°) (near $\delta$ *Lyræ*). | No good accordance with any previously known radiant-point. Course nearly vertical, descending at an inclination of about 15° or 20° from S.S.E. towards the N.N.W. |

Q

| 1876, Date and Hour, G.M.T. Size and General Appearance. | Places of Observation (available for calculation). | Meteor's Real Course (distances in B. S. Miles). | | | |
|---|---|---|---|---|---|
| | | Beginning: Height and Locality. | End: Height and Locality. | Radiant-point, observed. α δ | Nearest known Radiant-point. |
| Nov. 8, $5^h\ 4^m$ p.m. Large and bright, even in the twilight; fire-colour, with long train and string of globes at last; left no streak. | Wimbledon (Surrey) and Hay (S. Wales) for end-point and radiant-point. New Cross (London), and other corroborations in the S. of England. Long, nearly horizontal course of 240 or 300 miles (?) in "4 or 5 secs." (Wimborne, Hants; no estimates are recorded of its entire duration.) Leisurely horizontal motion "towards S. or S.W.," at every place; (towards W. at Manchester). | 50 miles over Sheffield, or 55 miles over Hull and Hornsea (alt. 20° due N. from London. This early commencement, and the length of flight at last, are somewhat inconsistent with other observations). | 37 miles over the Irish Channel, 60 or 70 miles W. of Milford Haven. An earlier termination of the meteor on this line of flight, over Aberystwith is indicated by a good observation of its apparent course at Manchester. | 53° + 20° (± 5°) (near η *Tauri*). | A *Taurid.* The whole real course is presumptive, assuming the observed altitude at Hay 20° or 25° due West to be measured and accurate. The adopted general rad.-point, however, admits of very little variation or correction. |
| 1877, Jan. 7, $10^h\ 31^m\ 30^s$ p.m. = ♀; yellow, and red sparks in train. Long, slow, irregular course; died out; left no streak. | Birmingham, Putney Hill, and neighbourhood of London (the exact place not specified). | 76 miles over Staplehurst, Kent. First expansion at 67 miles over the channels of the Thames and Blackwater River, Essex (end and beginning points as seen in London). | 33 miles over the North Sea, 25 miles N. and 90 miles E. from Cromer, Norfolk (Birmingham termination). | 44° − 16° to 65° − 13° (near γ *Eridani*; not conformable to any known meteor-shower). | Length of path 104 miles (London); 185 miles (Birmingham, ? overrated; and duration "5 to 6 secs." there). Theoretical meteor speed 12·3 miles per second. |

In addition to the above accordant observations, simultaneous records of 15 or 20 bright meteors and shooting stars, chiefly between Mr. W. F. Denning's station at Bristol, and the Radcliffe Observatory, Oxford, have been obtained, of which the particulars will afford available materials for calculation. The times of appearance and general description of other considerable meteors during the past year, as far as accounts of them have been received, appear to have been as follows:—

| Date. | | |
|---|---|---|
| 1876, Feb. 4 | $7^h\ 35^m$ p.m. | Nucleus with globular disk several minutes in diameter; seen moving slowly westwards, in the south, at Bristol. |
| 1876, Mar. 19 | Paris Time.<br>$11^h\ 13^m$ p.m. | Fireball recorded by M. Chapelas Coulvier Gravier, at the Observatory of the Luxembourg, in Paris. |
| 1876, April 15 | $8^h\ 33^m$ p.m. | Meteor with a bright disk; seen in the western twilight at Bristol, and at Hawkhurst (Kent). |
| 1876, July 8 | Wash. M.T.<br>$8^h\ 45^m$ p.m. | Indianopolis, and Indiana State, U.S. A fireball of the largest class; half the appar. diam. of the Moon, leaving a streak of light for $40^m$; no detonation heard. Traversed an arc of 30° north-westwards from *Cassiopeia*. |
| 1876, Aug. 21 | $8^h\ 10^m$ p.m. | Bolide with large elongated nucleus. Manchester; and at London and Sheerness. (Fell in the north.) |
| 1876, Aug. 22 | $8^h\ 40^m$ p.m. | At Scarborough; very bright. Fell in the E.S.E. nearly to the sea, from alt. about 60° in the S.E. |
| 1876, Nov. 5 | Paris Time.<br>$8^h\ 40^m$-$9^h$ p.m. | Large fireball. Departments of Marne and Aube, France; a detonation is said to have been heard in the latter district at Clery. At Choisi-le-Roy the meteor's course was from α *Aurigæ* to α *Ursæ Majoris*, and along this line it left a momentary streak. The meteor's course is directed from *Taurus* and *Auriga*. |
| 1876, Nov. 6 | $5^h\ 45^m$ p.m. | A large fireball at Orsay, Paris, moving slowly at a low altitude in the E.N.E. southwards. Bright, but smaller than the Moon's disk, leaving a slight streak on its course. Very probably a "Taurid" seen with slow foreshortened course near its radiant point. |

| | | |
|---|---|---|
| 1876, Nov. 6 | Between $8^h$–$9^h$ p.m. | A large meteor seen in Kent, Herts, and Lancashire, descending almost vertically in N. and E. (Kent and Herts), and in the West (Lancashire); (?) two meteors. Divided into two parts, or disappeared with two separate explosions. Not directed from *Taurus*. |
| 1876, Nov. 7 | $7^h$ $19^m$ p.m. | Fireball in *Capricornus*; Writtle (Essex). Burst with a bright flash 6° under *β Capr.* Path 10° in 3 seconds, directed from *Saturn*. Very probably a distant " Taurid." |
| 1876, Dec. 13 | $4^h$ $45^m$ p.m. | A bright fireball, in daylight, when very few stars were yet visible; seen from near London, Farnborough (Hants), &c.; in the N.E. descending from west to east with a course of some length to near the E. horizon. Yellow, bluish green, and red at last, with a trail of sparks, which remained visible for a few moments. The descriptions of this fireball's course correspond very nearly with that of the daylight meteor of December 22, 1875, at $1^h$ $40^m$ p.m., described in the last volume of these *Notices*;* and it appertains not improbably to a meteor-system of the same group, with a radiant-point near *β Herculis*. |

Of the real courses of the many bright meteors here described very little is accurately known, and it is much to be desired that in describing apparitions of such remarkable phenomena observers would endeavour to ascertain correctly and express clearly the apparent positions in the sky of the tracks along which these celestial intruders upon the Earth in its motion round the Sun pass across their field of view.

The periodical star showers of the past year have been either inconspicuous or much concealed by cloudy weather, and scarcely any notes of them of very remarkable importance were obtained. A meteor shower of some intensity was observed on the night of the 18th of April 1876, at Bloomington, Indiana, U.S., of which the appearance was recorded, and some particulars were gathered by Professor Kirkwood, of the State University of that town. The meteors were sufficiently numerous and bright to attract the attention of ordinary observers, and from their description the radiant point of the shower appears to have been in the neighbourhood of the constellation

---

* Vol. xxxvi., p. 217.—*Erratum*: line 19 from bottom of the page, *for* Brangling, *read* Braughing.

*Lyra.* As the year was a leap-year the expected time of appearance of the shower would be on the 18th instead of on the 19th-20th of April as it returns in ordinary years. Another meteor shower of greater brilliancy was observed on the night of October 18, 1876; and its appearance was similarly recorded by Professor Kirkwood from the concurrent testimonies of numerous observers of the many bright meteors which were visible at Bloomington on that night. The radiant-point was in *Auriga* or between *Taurus* and *Auriga*, and it may not impossibly have been distinct from the usual maximum recurrence of the well-marked shower from *Orion* on that date. From the narrative (above quoted) of the appearance of a large meteor (perhaps aërolitic) early on the following morning in Massachusetts, it may also be added that frequent small shooting stars were still visible there at $2^h$ a.m. on October 19, and it is said that two or three of the shooting stars seen at Bloomington between $9^h$ $45^m$ and $11^h$ $15^m$ p.m. on the 18th were noticed to be exceedingly conspicuous by their size and brightness. Of these and other star showers, with the exception of that of August last, no observations were obtained in England. The sky was clear during the period of the August shower, but the Moon had scarcely passed its full, and was unfavourable to observations in the later hours. The maximum of the shower occurred on the night of the 10th, and it was so unimportant in intensity compared with many previous displays that one observer watching a clear sky could at the most only count about 25 or 30 *Perseïds* per hour together with 10 or 12 sporadic shooting stars, while the numbers seen on the nights of the 9th and 11th were much less than this. Even allowing for the effect of the Moon's light in extinguishing the smallest meteors of the *Perseïd* shower, the observations all indicated very clearly a distinctly marked diminution in the intensity of the August showers in 1876 as compared with its brightness in 1875, and in several of the immediately preceding years. Among the records of the shower in England are several simultaneous observations, two of them of bright *Perseïds* (on August 11 and 13) and one of an *Aquilid* or *Aquariad* on the 15th, of which only a few calculations (those above described) have yet been brought to a conclusion. The radiant point of the shower was accurate, in spite of its faintness, near η *Perseï*; but the presence of another radiant point in *Cassiopeia* was also recognised on certain nights of the shower as exhibiting simultaneously with it a very marked activity, which scarcely, however, permitted its position to be very accurately determined. Watches were maintained without success at well-equipped stations and under favourable conditions of the sky for the *Leonids* and *Andromedes* of November 1876. At Clermond Ferrand, in France, Mr. Gruey, assisted by one companion during a part of the watch, saw only five meteors on the first and even fewer falling stars on the second morning during intervals of four hours' duration, each after midnight a.m. of November 13 and 14, although the sky was clear. During the hour from $2^h 30^m$ to $3^h 38^m$ on the morning of November 15, when the sky was very clear, only one meteor was observed. None of these shooting stars appear to have been conformable to the radiant point in *Leo*. The observations of the same shower in 1875, including those communicated last year to the Astronomical Society by the Astronomer-Royal,* clearly indicate that the November shower has ceased to be conspicuous on the accustomed dates; but a progressive tendency of the shower to reach its maximum on the morning of the 15th instead of the 14th of November, observable in the years ending with November 15, 1872, is noticeable in all more recent observations of the *Leonids*, and may have continued to retard its date, unperceived by observers on the ordinary nights of observation, since that time. Three small *Leonids*, leaving white streaks for two or three seconds, seen near the radiant point in *Leo* by Mr. Denning, at Bristol, on the morning of November 19 (with two others on the following morning), diverging accurately from a point at R.A. 149°, Decl. +22° †, together with the absence of any such indications of the shower in France on the mornings of the 13th-15th of November last, may perhaps be accounted for by a considerable deformation of the meteor stream, and a consequent sensible change of position of its nodal points, in the portions forming the terminal or retreating phases of the shower.

No indications of the *Andromedes* were observed by Mr. Denning on later mornings of November, and a watch for them kept at other stations on the last few evenings of the month, when the sky was clear, was also without success. The shower of the "Geminids" of December 12 appears to have furnished a large proportion of shooting stars as early as December 8 and 9; but cloudy skies on the following nights prevented the time of its maximum from being ascertained. No observations on the periodic shower-date of January 1-3, 1877, have yet been received, and it is to be feared that the unfavourable conditions of the full Moon and cloudy weather have again prevented this rarely distinguishable star shower from being satisfactorily observed.

The observations of shooting stars at the Radcliffe Observatory, Oxford (included in the publications of that Observatory for the year 1874), continued to be recorded with accuracy and amplitude during the past year; and fifteen of the meteors registered are identifiable with meteors of various magnitudes which have been elsewhere observed, and whose real paths it will be possible to compute with some precision. The Luminous Meteor Committee of the British Association has resumed its examination of these and of other meteor tracks communicated to it by observers, with a view to presenting in the most convenient form for their constant reference a table and map of the centres or regions of divergence of shooting stars on ordinary nights of the year, at present known with the greatest certainty to exist; and a key-map and table, constructed for this purpose by Mr. Greg, were presented, with the Report of the Committee, to the British Association in September last, as the first completed stage in the progress of their undertaking. It is also intended to embody the catalogue and map with the original lists of meteor showers by individual observers from which it is constructed, in a suitable tract or pamphlet, with instructions for recording, and directions of the days most desirable for registering shooting stars, to serve observers as a useful ephemeris to guide them in their observations; and this design the Committee hopes during the coming year to be able to carry out.

---

* *Monthly Notices*, vol. xxxvi., p. 272, March 1876.

† For easy representation of the lengths of paths, altitudes, and azimuths of meteors, etc., in degrees, it is found convenient to employ this mode of reckoning R.A. instead of the usual method of expressing it in time, and to describe declinations north or south of the Equator with a + or − sign, as a brief way of recording the apparent paths, and hence also most conveniently in charts of this description, the positions of the radiant points of shooting stars.

## *Report of the Auditors.*

The following Report of the Auditors was presented to the meeting at the conclusion of the reading of the Report of the Council, in conformity with bye-law No. 65. The balance-sheet of the Auditors, however, differs in arrangement in some minor particulars from that of the Treasurer, presented to the Council and printed in their Report, but the balances in hand as stated in the two balance-sheets are precisely the same.—[E. D.]

"We, the undersigned, being the Auditors appointed, at the meeting of this Society held on the 12th of January last, to examine the accounts of the Society, in pursuance of the 65th bye-law, for the year ending 31st of December 1876, do report as follows:—

"1. The paper writing hereto annexed and marked A, and verified with our signatures, contains a true and correct statement of the receipts and expenditure of the Treasurer, on account of the Society, from the 1st of January to the 31st of December 1876, inclusive.

"The available balances in the hands of the Bankers and the Secretary of the Library Committee amounted to the sum of £270. 15*s*. 5*d*.

"2. The paper writing hereto annexed and marked B, and also verified with our signatures, contains a true statement of the funded property of the Society on the same day, as far as we are able to ascertain it.

"3. We have examined, as far as circumstances would permit, the state of the rest of the property of the Society, consisting of

"Instruments;
"Books in the Library;
"Stock of the Society's Publications.

"With regard to the instruments, we have to report that some of them, viz. Nos. 11, 21, 32, 64, 66, 68, 71, 73,* and 79 in the list contained in the Report of the Council in 1876, are missing. The remainder, including Nos. 28 and 49 in the same list, which have been found since that report, are, with few exceptions, in good order and preservation. We have not thought it necessary to enter into minute particulars on this subject, as a very careful examination of them was made previously to the last general meeting by Mr. Lecky, the principal part of whose report was inserted in the *Monthly Notices* of February last.

---

* No. 73 has been removed from the list of the Society's instruments by order of the Council.—[E. D.]

"As no catalogue of the books in the library has been formed, we are unable to say whether they are correct in point of number. We strongly advise, in the general interest of the Society, that a catalogue should be made as soon as possible.

"We have had the same difficulty in dealing with the stock of the Society's publications as was mentioned by the Auditors of last year, though not by any means to the same extent. It is, and always will be, exceedingly difficult to check the issue of individual copies of each of the *Memoirs* and *Monthly Notices*, but they are now in a very much better state than at the last audit. The perfect volumes have been carefully packed in parcels, with the number of copies contained marked on each. We have not examined the whole, but have opened some half-dozen, selected by chance, and have in every instance found the number to correspond with the label.

"FRANCIS BARROW.
"ARTHUR BREWIN.
"J. KENNEDY ESDAILE.

"*February* 8, 1877."

A.

## RECEIPTS.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance at Bankers', Dec. 31, 1875 | 548 | 18 | 9 | | | |
| „ in hand of Secretary of Library Committee: | | | | | | |
| on account of Library Expenses | 32 | 3 | 0 | | | |
| „ Turnor Fund | 21 | 0 | 0 | | | |
| „ in hand on Petty Cash Account | 13 | 4 | 11 | 615 | 6 | 8 |
| Dividend on £3,700 Consols | 55 | 0 | 9 | | | |
| „ £5,200 New 3 per Cents. | 77 | 7 | 0 | | | |
| „ £4,000 Consols | 59 | 5 | 0 | | | |
| „ £5,200 New 3 per Cents. | 77 | 0 | 6 | 268 | 13 | 3 |
| Received on account of Subscriptions: | | | | | | |
| Arrears of Contributions | 106 | 1 | 0 | | | |
| 237 Contributions for 1876 | 497 | 14 | 0 | | | |
| On account of do. | 2 | 0 | 0 | | | |
| 28 Admission Fees | 60 | 18 | 0 | | | |
| 20 First Contributions | 32 | 11 | 0 | 699 | 4 | 0 |
| 11 Composition Fees | | | | 231 | 0 | 0 |
| Sale of Publications at Society's rooms | 52 | 18 | 8 | | | |
| „ at Williams & Norgate's | 23 | 1 | 0 | 75 | 19 | 8 |
| Balance of Horrox Memorial Fund | | | | 38 | 15 | 0 |
| Bequest of the late T. C. Janson, Esq., to the Lee Fund | | | | 200 | 0 | 0 |
| Due to Assistant Secretary, Dec. 31, 1876, on Petty Cash Account | | | | 2 | 18 | 8 |
| Due on outstanding cheque | | | | 15 | 0 | 0 |
| | | | | £2,146 | 17 | 3 |

A.

## EXPENDITURE.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Salaries:— | | | | | | |
| Editor of *Monthly Notices* (five quarters) ... | 75 | 0 | 0 | | | |
| Assistant Secretary (five quarters) ... ... | 187 | 10 | 0 | | | |
| | | | | 262 | 10 | 0 |
| Income Tax and House Duty ... ... ... | | | | 5 | 5 | 0 |
| Fire Insurance ... ... ... ... ... | | | | 7 | 16 | 6 |
| Printing:— | | | | | | |
| Spottiswoode & Co. ... ... ... ... | 364 | 8 | 0 | | | |
| Hazell, Watson, & Viney ... ... ... | 187 | 12 | 0 | | | |
| Holdgate Bros. (printing plates) ... ... | 18 | 5 | 0 | | | |
| | | | | 570 | 5 | 0 |
| Lithography, Engraving, &c.:— | | | | | | |
| Chatham School of Photography ... ... | 5 | 10 | 0 | | | |
| W. H. Wesley ... ... ... ... | 51 | 2 | 0 | | | |
| | | | | 56 | 12 | 0 |
| Binding and Stitching: J. Rumfitt ... ... | | | | 39 | 17 | 3 |
| Library expenses, binding books, &c. ... ... | | | | 138 | 14 | 6 |
| Turnor Fund: Books purchased during year ... | | | | 48 | 16 | 3 |
| Miscellaneous:— | | | | | | |
| House expenses ... ... ... ... | 28 | 7 | 7 | | | |
| Wages ... ... ... ... ... | 23 | 17 | 0 | | | |
| Stamps and postage ... ... ... ... | 49 | 10 | 8 | | | |
| Carriage of books and parcels ... ... | 8 | 8 | 2 | | | |
| Stationery and office expenses ... ... | 8 | 6 | 0 | | | |
| Expenses of meetings ... ... ... | 17 | 15 | 6 | | | |
| Coals and gas ... ... ... ... | 74 | 19 | 9 | | | |
| Mrs. Jackson-Gwilt's annuity ... ... | 8 | 19 | 0 | | | |
| Fittings in Library &c.: Whitechurch Bros. | 5 | 14 | 6 | | | |
| Sundries ... ... ... ... ... | 20 | 19 | 8 | | | |
| Bankers' commission &c. ... ... ... | 0 | 0 | 6 | | | |
| New Cheque-book ... ... ... ... | 0 | 8 | 4 | | | |
| | | | | 247 | 6 | 8 |
| Investments:— | | | | | | |
| Purchase of £300 Consols, at $96\frac{3}{8}$, including Commission ... ... ... ... | 289 | 10 | 0 | | | |
| Purchase of £200 Consols, at $95\frac{5}{8}$, including Commission ... ... ... ... | 191 | 10 | 0 | | | |
| | | | | 481 | 0 | 0 |
| Balance at Bankers', Dec. 31, 1876 ... ... | 253 | 1 | 10 | | | |
| In hand of Secretary of Library Committee: | | | | | | |
| On account of Library expenses ... ... | 13 | 8 | 6 | | | |
| „ Turnor Fund ... ... | 22 | 3 | 9 | | | |
| | | | | 288 | 14 | 1 |
| | | | | £2,146 | 17 | 3 |

Francis Barrow.
Arthur Brewin.
J. Kennedy Esdaile.

## B.

Assets and present Property of the Society, January 1, 1877:—

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance at Bankers', Dec. 31, 1876 ... ... ... | 253 | 1 | 10 | | | |
| Less amount of outstanding cheque ... ... | 15 | 0 | 0 | | | |
| | | | | 238 | 1 | 10 |
| Due on account of subscriptions:— | | | | | | |
| 2 contributions of 5 years' standing ... ... | 21 | 0 | 0 | | | |
| 2 ,, 4 ,, ... ... | 16 | 16 | 0 | | | |
| 11 ,, 3 ,, ... ... | 69 | 6 | 0 | | | |
| 22 ,, 2 ,, ... ... | 92 | 8 | 0 | | | |
| 69 ,, 1 ,, ... ... | 144 | 18 | 0 | | | |
| 2 admission fees ... ... ... ... ... | 4 | 4 | 0 | | | |
| 2 first contributions ... ... ... ... | 2 | 2 | 0 | | | |
| and one amount of ... ... ... ... | 5 | 5 | 0 | | | |
| | | | | 355 | 19 | 0 |
| Balance in hand:— | | | | | | |
| In hand of Secretary of Library Committee: | | | | | | |
| On account of Library expenses ... | 13 | 8 | 6 | | | |
| On account of Turnor Fund ... ... | 22 | 3 | 9 | | | |
| | 35 | 12 | 3 | | | |
| Less amount due to Assistant Secretary on Petty Cash Account, Dec. 31, 1876 | 2 | 18 | 8 | | | |
| | | | | 32 | 13 | 7 |

£5,200 New 3 per Cents., including Mrs. Jackson-Gwilt's Gift (£300).

£6,200 Consols, including the Lee Fund (£300); the Turnor Fund (£450); the Horrox Memorial Fund (£100); and Mr. Carrington's bequest of £2,000 Stock which has been transferred to the Society during the past year.

Unsold Publications of the Society, various astronomical instruments, books, prints, &c.

Two Gold Medals in stock.

Balance of Turnor Fund included in Treasurer's Account, £129. 5*s.* 6*d.*

Francis Barrow.
Arthur Brewin.
J. Kennedy Esdaile.